Winter 2009

DroughtScape- Winter 2009

Kelly Smith

National Drought Mitigation Center

DroughtScape

The Newsletter of the National Drought Mitigation Center

Winter 2009

Bastrop TX: Feb. 12
Central CA: Feb. 24, 26

Workshops and listening sessions have been scheduled to introduce and get feedback on the suite of drought management tools that the NDMC is developing. Please see page 14 for more information about how to register.

Big Canoes to Launch

Sign up soon to be sure you're on board for the inaugural issue of *The Big Canoes*. The newsletter, published by the Center for Research on the Changing Earth System, will provide regular updates on developing drought and flood predictions for the Missouri River based on decadal climate variability. Read more about the project on page 15.

NDMC Welcomes Widhalm, Sakamoto

The NDMC is pleased to add Melissa Widhalm, a climatologist, to our staff. She is profiled on page 10.

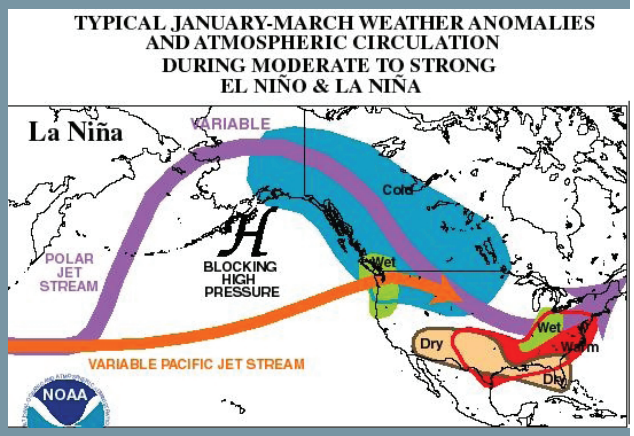
The NDMC's GIScience and Analysis program area is getting a boost from visiting scientist Toshihiro Sakamoto. Please read his profile on page 11.

Have an Idea to Share?

To arrange to contribute to *DroughtScape,* please email ksmith2@unl.edu.

La Niña May Keep West and Gulf Coast Dry

La Niña weather patterns are likely to continue through the winter and into spring, so drought may continue in the west. For the complete quarterly Outlook and Summary, please see page 2.



2008 in Review

Drought improved across much of the U.S. in 2008, although the Southeast and California saw drought linger all year, and exceptional drought emerged in Texas. The good news was that as of the end of the year, the U.S. was as drought-free as it has been at any time since October 2005. Please refer to the full summary of 2008 on pages 4 and 5.

U.S. Feels Drought Impacts in 2008

The U.S. Drought Impact Reporter captured 2,300 impacts in 2008.

For an impacts overview, please see pages 6 and 7.

For a sample of California impacts from 2008, please see pages 8 and 9.

Climate Modelers at Workshop Look to Sea Surface Temperatures for Drought Prediction

Climate modelers from across the U.S. gathered in Lincoln, Nebraska, in October 2008 to share their findings. David Legler, director of the U.S. Climate Variability and Predictability Research Program and an organizer of the workshop, said it was "the first time the climate research community has come together in a concerted way to look at prospects for predicting drought."
Read more on pages 12 and 13.

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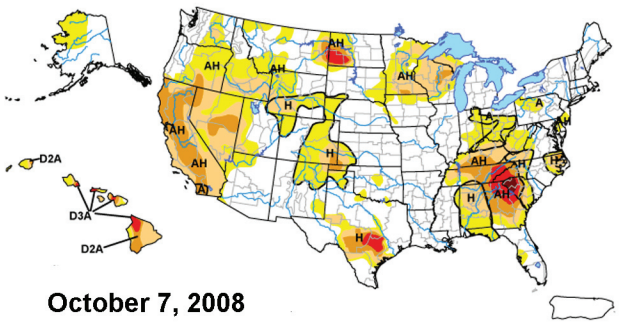
Winter 2009 Outlook and October to December Summary

By Brian Fuchs, Climatologist, National Drought Mitigation Center

Drought classifications are based on the U.S. Drought Monitor. For a detailed explanation, please visit http://drought.unl.edu/dm/classify.htm. The outlook integrates existing conditions with forecasts from the National Oceanic and Atmospheric Administration's Climate Prediction Center: http://www.cpc.ncep.noaa.gov/

Outlook: La Niña will continue to develop and linger for the rest of winter and into spring. With La Niña, we can typically expect dryness over much of the western United States, Florida and the southern Gulf Coast states. The forecast for La Niña has shown a longer and slightly stronger episode developing over the next few months. We should continue to see improvements over the Ohio River Valley, as this area typically is wetter than normal under La Niña conditions. The Pacific Northwest should also continue to see the active weather pattern, bringing ample moisture along the coast.

October: At the start of October, 42.9 percent of the United States was abnormally dry or in drought, and this only improved to 40.1 percent by the end of the month. Several areas across the country were in extreme and exceptional drought. Extreme drought (D3) was affecting Texas, California, Hawaii, Tennessee, Georgia, North Carolina and South Carolina, while exceptional drought (D4) lingered in South Carolina. October saw much of the West and Southeast receiving below-normal precipitation, while the High Plains and Mississippi Valley regions received above-normal precipitation for the month.



October 7, 2008

November: Overall, conditions for the United States worsened during November, with 43.4 percent of the country suffering from abnormally dry or drought conditions at month's end. Most of the new dryness on the Drought Monitor came in the western United States, as the new water year started with deficits in both rain and snowfall. Exceptional drought spread throughout the Carolinas and into Georgia. Long-term hydrological impacts continued to worsen as much of the Southeast received less than 25 percent of normal precipitation for November, bringing three-year precipitation deficits to more than 20 inches through most of the region.

Q: What is a Water Year?

A: Just as fiscal years don't always coincide with calendar years, agencies that collect data about water sometimes find it more convenient to use 12-month periods that begin and end in dry seasons. The U.S. Geological Survey, which collects and disseminates a lot of water data, uses a water year that begins October 1 and ends September 30.

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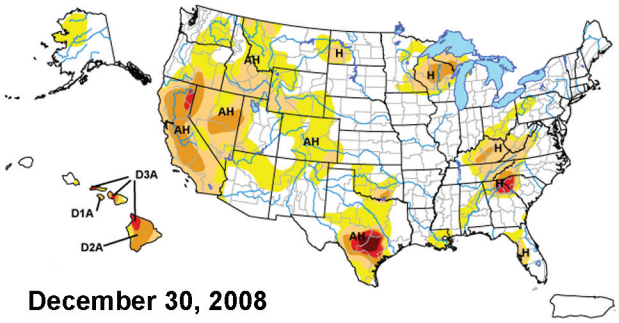
October to December Summary, continued

December: Drought conditions improved substantially in December. The month ended with 38.9 percent of the United States abnormally dry or in drought, compared to 43.4 percent at the beginning of the month. Moderate to exceptional drought affected just 16.2 percent of the country, compared with 18.2 percent at the start of the month. That was the smallest spatial extent of drought shown on the Drought Monitor since October 2005. The intensity of drought over the Southeast and Ohio River Valley decreased in December. D4 in the Southeast subsided to D3, and the area of D3 was confined to portions of Georgia and South Carolina. Dryness continued to hamper Texas, as drought intensified over the southern part of the state. Severe to exceptional drought affected 15 percent of the state at the end of the year.



December 30, 2008

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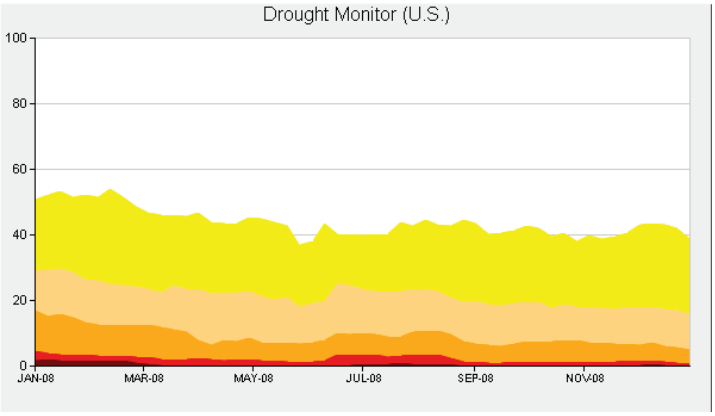
2008 Year in Review

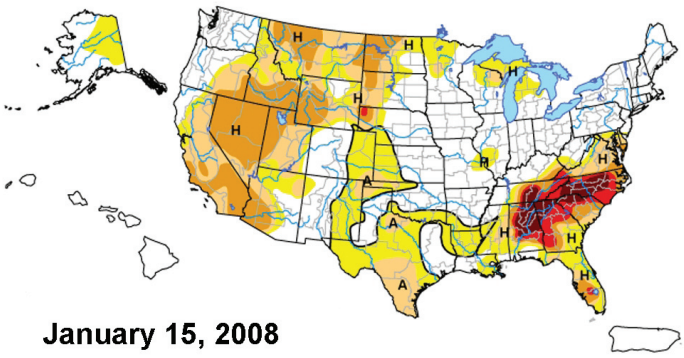
By Brian Fuchs, Climatologist, National Drought Mitigation Center

Drought classifications are based on the US Drought Monitor. For a detailed explanation, please visit http://drought.unl.edu/dm/classify.htm.

The United States saw widespread reductions of drought in 2008, although at year's end, south central Texas was in exceptional drought, California and Nevada were covered by drought, and drought persisted in a shrinking area of the Southeast.



Going into 2008, the Southeast was suffering from a multi-year drought, while the western United States was going into a second year of below normal precipitation and snowpack. Milestones from the year:



- The spatial extent of dryness and drought peaked for 2008 in mid-February, with 54.1 percent of the United States abnormally dry or in drought (D0-D4).
- Drought conditions (D1-D4) were at their greatest extent in mid-January, when 29.8 percent of the United States was in moderate to severe drought, centered over the Southeast and West.
- At year end, 39.9 percent of the United States was depicted as abnormally dry or in drought (D0-D4), with only 16.2 percent showing moderate to exceptional drought (D1-D4). This was the smallest spatial extent of drought over the United States since October 2005.

Winter

A dry winter expanded and worsened drought in both the southern and northern Plains states. During this time, portions of North Dakota, Montana, Colorado, and South Texas reported precipitation amounts below 50 percent of normal, while the drought designation rapidly went to D3 in North Dakota and D4 in south Texas. During this time, rains returned to the Southeast, bringing much-needed drought relief to Alabama, Georgia, Tennessee, and the Carolinas. The rains helped a lot with short-term dryness, while longer-term issues, such as reservoir storage and water table levels, were slower to respond and were still problematic.

2008 Year in Review, continued

Spring
Beneficial rains continued in the Southeast, and the drought continued to improve. The Plains states were a mixed bag during this time. Dryness and drought expanded over North Dakota and into Montana and South Dakota, while rains in Texas brought some relief. The extreme drought conditions in south Texas were improved, but overall, the moderate to severe drought expanded into west Texas and into New Mexico. San Antonio measured its driest September-May since 1872, with only 6.57 inches of rain. Southeast Colorado, southwest Kansas and the Panhandle of Oklahoma missed out on much of their winter precipitation, as well as spring rains. Extreme drought was introduced into this area, and winter wheat crop failures were widespread.

The wet winter had eased California's drought, but abnormally dry weather took over for the rest of the rainy season, from March to May. With cumulative precipitation less than 25 percent of normal, spring 2008 ranked as the driest in more than 100 years of records. By the end of May, drought had returned to much of the state. Over much of the Midwest, rain was the story in the spring, with the fifth wettest spring in 114 years. Areas from Missouri to Indiana recorded their wettest spring on record.

Summer
During the summer, drought intensified. In the Southeast, extreme and exceptional drought conditions returned and expanded in the Carolinas, Georgia and Tennessee. Below normal precipitation and lingering impacts left this region highly vulnerable to a relapse into more intense drought. By the end of summer, conditions in the northern High Plains improved, but the rains came too late, as crop losses in North Dakota and Montana were substantial. Severe drought expanded in California, covering 43 percent of the state by the end of August. In Hawaii, despite floods earlier in the year, a dry spring and summer brought drought. By the end of summer, Oahu, Maui and the Big Island were experiencing severe to extreme drought.

Fall
Winter weather brought abundant early season snowfall in the Rocky and San Juan Mountains, and improvements to drought over southeast Colorado and into the Four Corners region. Rains in the Southeast reduced drought again, with only Georgia and South Carolina showing extreme drought by the end of the year. Even though precipitation for 2008 was at or above normal for many locations, long-term issues lingered in the Southeast. The extreme drought in North Dakota improved to moderate drought by the end of December. Drought continued to develop over the southern Plains and California, with well below normal precipitation totals since the start of the current water year on October 1. The past few years in Texas have seen highly variable rainfall. For example, Victoria, Texas recorded 71.9 inches of rain in 2007, the most on record, and in 2008, they had just 21.7 inches, the fifth driest year ever.

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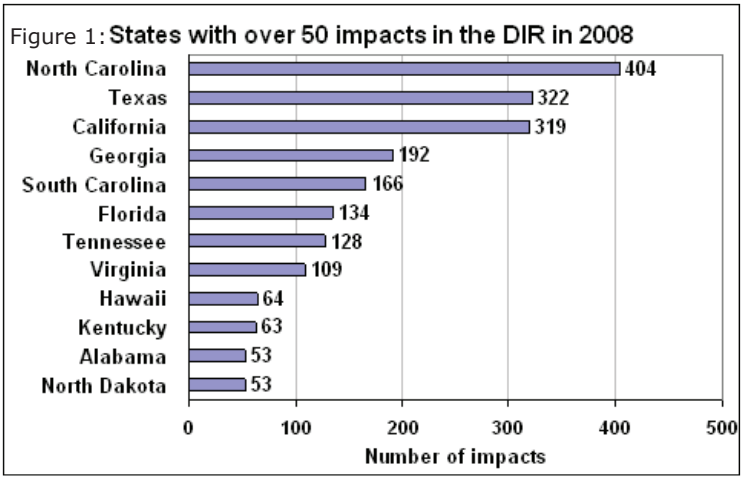
2008 Drought Impact Reporter Summary

by Denise Gutzmer, Drought Impact Reporter Moderator

NDMC moderators entered more than 2,300 impacts into the Drought Impact Reporter in 2008 as dry conditions plagued the southeastern U.S., much of the western part of the country, and other areas, such as North Dakota, Texas and Oklahoma.

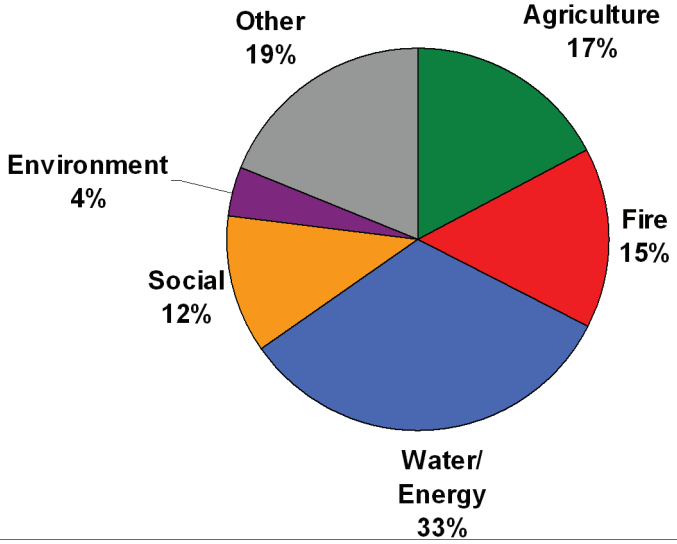
The greatest number of impacts was reported in North Carolina, with 404 entries, while Texas and California followed close behind with 322 and 319 entries, respectively. Other states with 50 or more impacts in 2008 are shown in Figure 1. Among the most frequently reported impacts were water shortages and restrictions, agricultural losses, and diminished hydropower production.

Figure 1: States with over 50 impacts in the DIR in 2008



When the entries for the Drought Impact Reporter are analyzed by category (Figure 2), 33 percent of the impacts entered described water and energy concerns, such as depleted water reserves, leading to voluntary or mandatory water restrictions, dry wells, curtailed irrigation, reduced hydropower production, and curtailed navigation.

Figure 2: DIR entries for 2008 by category



The second largest category of impacts recorded in the DIR was "Other," at 19 percent, which mainly contains information about responses to drought, such as disaster declarations, drought watches and warnings, and relief programs.

Agricultural impacts were the third most frequently reported, at 17 percent of the total. This included reports on how traditional farmers and ranchers were affected by drought, as well as tree farms and aquaculture.

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2008 Drought Impact Reporter Summary, continued

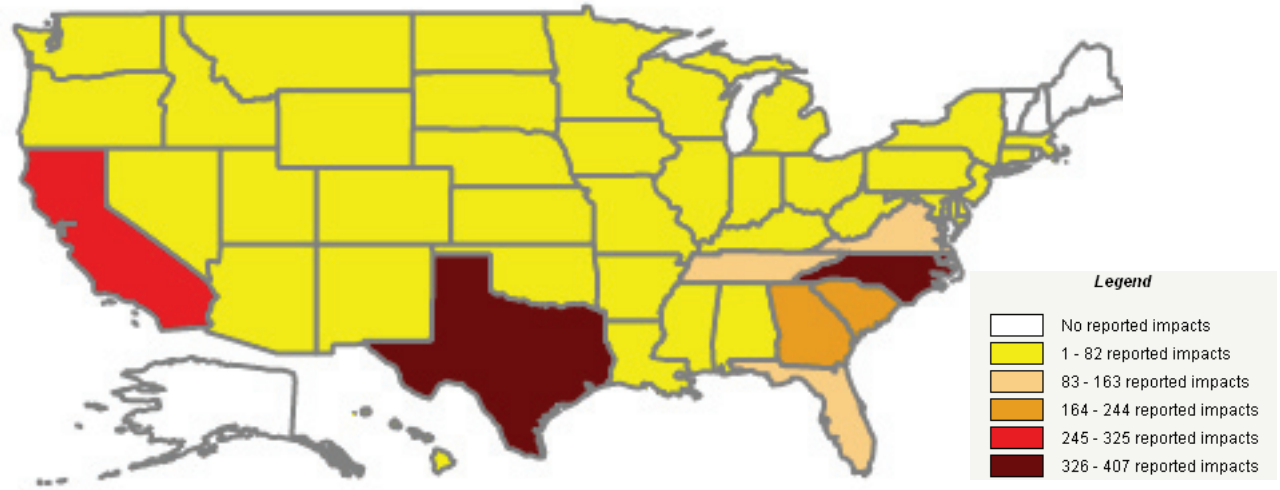
Fifteen percent of the DIR entries described fire impacts, including burn bans that restricted fire and fireworks, wildfire, and damages from wildfire. Our moderators make an attempt to distinguish normal fire from drought-related fire.

Social impacts made up 12 percent of the entries. They describe drought-related behavior changes reported in the media, such as anxiety, water conservation measures, and donations to assist others affected by drought.

The least-used category in 2008 was Environment, representing 4 percent of the entries. Drought often leads to food and water scarcity for animals and brings them into residential areas in search of food. Media reports included declines in the population of particular species and trees dying from a lack of water.

Some areas such as the Oklahoma Panhandle suffered severe drought in 2008, but few if any impacts were reported. Drought impact reporting depends in part on the presence of media and how much other news is going on at the same time. Our search engine only picks up stories that are distributed on the web, so it may miss news from weekly newspapers in remote rural areas. We're working on developing more sources of information for the Drought Impact Reporter, including on-the-ground observations. If you'd like to become a regular contributor of drought reports, please contact Kelly Smith, ksmith2@unl.edu, 402-472-3373, for more information.

Drought Impact Reporter, Jan. 1-Dec. 31, 2008



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California Drought, 2008

This table provides a small, chronological sample of drought impacts from California in 2008. The number under each month is the total number of impacts reported for that month in the state. The colored bars show the greatest intensity of drought on the U.S. Drought Monitor for California each month. The reports shown here were gathered by the NDMC's Drought Impact Reporter moderators from media stories. All are in the Drought Impact Reporter, which has been on-line and updated continuously since July 2005: http://droughtreporter.unl.edu/

Month Impacts	D0	D1	D2	D3	D4	Impact Description
January **26**						San Diego water officials were urging residents to conserve water in the face of potential water supply stress. Santa Ana residents received written requests for water conservation with their water bills.
February **19**						Kings County had been in a local drought emergency since June 19, 2007, and had renewed the declaration every two weeks since that time. The declaration continued through at least October 24, 2008.
March **65**						Water conservation was still strongly urged for residents of San Diego County in light of the 30 percent reduction in water from northern California and eight years of drought in the Colorado River basin. The director of water resources for the San Diego County Water Authority stated that they were in stage 2 of their drought management plan, but that the next stage of the water plan involved mandatory water restrictions.
April **67**						An avocado grower in Valley Center was one of many growers who were forced to cut down trees because they didn't have sufficient irrigation water to grow a crop this year due to water rate increases, a 30 percent reduction in water supply, and the potential demise of a discount program for agricultural water use. An area citrus grower cut more than 30 percent of his trees in March.
May **77**						In preparation for a difficult fire season, Cal Fire activated additional summer fire fighters weeks earlier than usual as wildfires arose. The fire season began roughly a month early because of strong winds and drought conditions. A Cal Fire captain stated that the lack of rain has left vegetation extraordinarily dry for early May.
June **116**						The governor of California, Arnold Schwarzenegger, proclaimed that the entire state was in drought, following two years of below-normal precipitation. The governor urged all Californians to reduce their water use to avoid or delay the possibility of water rationing in the event that the next winter was dry. The state Department of Water Resources was directed to expedite water transfers to areas most in need, to assist local water districts with water conservation, and to help farmers impacted by drought. The California Water Service Company (Cal Water) entered Stage 1 of its Drought Management Plan and asked its customers to reduce their water use by 10 percent. Water rates increased on July 1 to further encourage conservation. Roughly 2 million people are served by Cal Water, from Chico to the Los Angeles area.

California Drought, 2008, continued

Month Impacts	D0	D1	D2	D3	D4	Impact Description
July **105**						The Metropolitan Water District of Southern California deferred delivery of 25,000 acre-feet of water to allow the Central Valley Project and State Water Project Contractors to use the water for crop irrigation. The Westlands Water District planned to return the same amount of water to the Metropolitan Water District later in the year. The redistribution of the water supply was in response to the governor's declaration of drought emergency for nine counties in the Central Valley.
August **83**						Hunger became an enormous problem among unemployed farm workers in Mendota by August because they could no longer afford to purchase food. One grocer put boxes of old produce out behind his store for those who needed it; the boxes vanished quickly. The mayor stated that there was also a higher incidence of shoplifting because people could not afford to pay for medications. The unemployment rate was 40 percent.
September **76**						The California Department of Food and Agriculture estimated drought losses for the state to be $259.8 million. The loss from rangeland is $94.5 million; cotton, $61.5 million; processing tomatoes, $9.6 million; cattle, $7.4 million; melons, $7.1 million; alfalfa hay, $6.5 million; grain, $5.8 million; and various other crops, $6.6 million. The cotton losses are attributable to unplanted and abandoned fields. Commercial vegetable growers estimate their losses at $60.8 million. The estimated loss for Fresno County is $73.5 million; Kern County, $69.5 million; Stanislaus County, $12.9 million; Merced County, $12.8 million; Kings County, $10.9 million; and Tulare County, $3.3 million.
October **55**						Cables, brackets, and tailings from the era of the gold miners were revealed by the falling water level of Lake Camanche, located roughly 30 miles southeast of Sacramento. In some places, the foundations of historic bridges could also be seen. The lake was at 35 percent of capacity.
November **28**						The Department of Water Resources expedited the process of awarding $17 million for water conservation programs. The funds were being used for rebate programs, education and outreach, leak detection, and upgrading systems to improve efficiency.
December **13**						More than 100 families were unable to get food at their local food bank in Mendota, where unemployment was 40 percent after drought and court-ordered cuts in the water supply drastically cut agricultural production in the area. Six hundred families were served by the food bank.

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NDMC Welcomes Melissa Widhalm to Staff

Melissa Widhalm joined the National Drought Mitigation Center on November 1, 2008, as a climatologist. She was previously a graduate student with the NDMC, completing her master's degree in 2006 with a thesis on drought impact collection at the state level. Since coming to the NDMC in fall 2004, she has gained extensive experience with the NDMC's core mission and has worked on the Drought Impact Reporter in many capacities. She'll continue her work on the Impact Reporter, and will also be working on a new Drought Ready Communities project, a methodology for collecting economic impacts, and other projects, as needed and feasible.

"I've always been driven by natural hazards and by hazard mitigation and preparedness," Melissa said. "I've always been absorbed by the weather."

At first, it took the form of fear. As a young child growing up in the Chicago area, even rain frightened her. Her parents encouraged her to watch The Weather Channel and to learn more. "My fear grew into an interest, and then a passion. I always knew I wanted to do something with weather and climate." One particularly formative moment was when an F5 tornado struck nearby Plainfield, Illinois, in 1990, killing 29 and injuring 350. Her parents later took her to see the damage to help her understand that it was a very rare extreme event.

Melissa went on to study meteorology at Northern Illinois University, graduating in 2004. A course in natural hazard impacts "exposed me to the human dimensions of natural hazards," Melissa said. "I learned you can do more with your meteorology degree than just forecasting." It was that interest in interdisciplinary uses of meteorology that brought her to the School of Natural Resources at the University of Nebraska-Lincoln, where she specialized in Climate Assessment and Impacts.

Melissa is also working with NDMC founding director Donald A. Wilhite, who is now director of the School of Natural Resources, to develop a campus-wide Climate Change Initiative program of excellence.

Formerly Melissa Melvin, she got married in May 2008, and enjoys cooking, weather and landscape photography, and storm-chasing, when gas prices permit.

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NDMC Welcomes Visiting Scientist Toshihiro Sakamoto

In November 2008, the NDMC welcomed visiting scientist Toshihiro Sakamoto, who will be part of the GIScience and Analysis program area for two years. Sakamoto is from Japan's National Institute for Agro-Environmental Science, where he works in the Ecosystem Informatics Division. His time in the U.S. is supported by a fellowship from the Japan Society for the Promotion of Science.

Japan imports soybeans, wheat and maize from the United States. Sakamoto is interested in studying Japanese food security by better understanding agriculture in the U.S., especially how it is affected by climate change.

Sakamoto's primary work will be using time-series vegetation index data from the MODIS satellite sensor to develop new methods to map and monitor agricultural land-use practices for the Corn Belt and Great Plains, said Brian Wardlow, the GIScience lead.

Sakamoto is also interested in how ground-based remote sensing can validate satellite data, and has experimented with using ground-based cameras on timers at night to measure the volume and height of growing plants. Satellite-based remote sensing typically produces data about the color and coverage of plants.

Sakamoto completed his Ph.D. in 2008 and his B.S. in 2002, both from Kyoto University. He has been with the Institute since 2004.

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Climate Modelers See Hope for Drought Forecasts in Sea Surface Temperatures

The key to more reliable drought forecasts for much of North America may come from learning how sea surface temperatures across the world's oceans are linked with rain and snow over land, say climate modelers, who are in the early stages of the research.

About 150 top climate scientists and others interested in drought gathered in Lincoln, Neb., Oct. 20-24, 2008, to share recent findings and discuss future directions for research. The National Drought Mitigation Center hosted the 33rd annual Climate Diagnostics and Prediction and Climate Variability workshops of the National Oceanic and Atmospheric Administration.

David Legler, director of the U.S. Climate Variability and Predictability Research Program, listens to a presentation during the 33rd annual Climate Diagnostics and Prediction and Climate Variability Drought Workshop, October 20-24, 2008, in Lincoln, Nebraska.

Scientists would like to be able to forecast drought. If farmers knew ahead of time that they were going into a drought year, they could choose drought-tolerant crops or plant less. If water managers could anticipate drought a few decades in advance, they could plan infrastructure, development, and river flows accordingly.

Climate modelers analyzing sea surface temperatures see a glimmer of hope for forecasting drought, said David Legler, director of the U.S. Climate Variability and Predictability Research Program and an organizer of the workshop. "The scientific community has demonstrated in the past five years that there might be some ability to predict drought," Legler said. He added that the workshop "is the first time the climate research community has come together in a concerted way to look at prospects for predicting drought."

Drought, which occurs nearly everywhere sooner or later, is a normal feature of climate with no single cause. "There are different styles of drought connected to different drought mechanisms," said Kelly Redmond, deputy director of the Western Regional Climate Center. "It isn't one-size-fits-all. Some come and go more rapidly."

Multi-year droughts, such as the one currently affecting the Colorado River Basin, appear most strongly connected to long-term sea surface temperature patterns. "When you get out two

Climate Modeling Workshop, continued

months or longer, you never get away from the oceans," said Siegfried Schubert, of NASA's Goddard Space Flight Center.

"We have to understand what's going on in the wettest parts of the world to understand dryness. They're connected," Redmond said.

One of the best-known global weather patterns is the El Niño-La Niña oscillation (ENSO), which links sea surface temperatures off the western coast of South America with dry and wet years in parts of Africa, Australia, and the southern United States. However, it has not proved to be an entirely reliable predictor of drought in North America.

Doug Le Comte, Climate Prediction Center, said that, based on the current cold Pacific and warm Atlantic, "there may be a trend for drought across the southern United States to continue through this fall and winter, but there's never much certainty when you're forecasting drought or anything else even a few days ahead of time."

Currently, scientists are deploying devices to measure various ocean characteristics, such as salinity, so they'll have much more complete data and a better understanding of how and when sea surface temperatures will change, said Jerry Meehl, of the National Center for Atmospheric Research in Boulder, Colo. "Everybody's kind of excited because nobody's failed yet," he said, referring to the inevitable trial and error involved in scientific discovery.

Until those global connections are better understood, managers should anticipate drier decades in the future because of climate change. "Even if the precipitation didn't change at all, as temperatures increase, evaporation increases," Meehl said. "That would tend to produce drier conditions in the future in some regions." In general, he added, scientists who study global warming anticipate that wet parts of the world will get wetter, and dry parts will get drier.

Meanwhile, until the global connections become clearer and reliable drought forecasts are a reality, "there's a lot of value in making better use of what we have available," Redmond said. "We might get taken by surprise by a flood, but we should never be taken by surprise by a drought. It's slow-moving."

Presentations from the workshop are online at
http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw33_proceedings/

NDMC in the Field

Please consider attending a workshop or listening session to learn about the suite of drought management tools that the NDMC is developing with sponsorship from the U.S. Department of Agriculture's Risk Management Agency.

Upcoming Workshops and Listening Sessions

Bastrop, Texas, February 12, 2009, hosted by the Lower Colorado River Authority

For on-line registration, the agenda, and other information, please visit:
http://drought.unl.edu/registration/TX2009/txregistration2009.html.

Coalinga, California, Harris Ranch, February 24, 2009
(VegDRI and VegOut Listening Session)

Woodland, California, Hedrick Agricultural History Center, February 26, 2009
For on-line registration, the agenda, and other information, please visit:
http://drought.unl.edu/registration/CA2009/caregistration2009.html

For more information on any upcoming workshop, please contact Nicole Wall, NDMC Public Participation Specialist, nwall2@unl.edu, 402-472-6776.

Recent Workshops and Listening Sessions

Presentations from the VegDRI and VegOut listening sessions in Walla Walla, Washington, November 11, 2008, are on-line at http://drought.unl.edu/news/listensession-WallaWallaWA2008.html.

Presentations from the Drought Monitoring Workshop and Listening Sessions in Cheney, Washington, November 12, 2008, are on-line at http://drought.unl.edu/news/listensession-CheneyWA2008.html.

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Project to Investigate Long-Term Weather Patterns in Missouri River Basin

Researchers are launching a new project to see how long-term climate patterns affect water, agriculture, and the economy in the Missouri River Basin. The NDMC is collaborating with the Center for Research on the Changing Earth System (CRCES) and the U.S. Army Corps of Engineers on a research grant, "An Assessment of Decadal Drought Information Needs of Stakeholders and Policymakers in the Missouri River Basin for Decision Support." It is supported by the National Oceanic and Atmospheric Administration.

One of the researchers' first steps will be to launch a quarterly electronic newsletter, *The Big Canoes: Decadal Climate Variability and the Missouri River Basin*. The newsletter will let readers know what patterns of decadal climate variability are occurring and will explore possible connections between these patterns and droughts or floods in the Missouri River Basin.

Some people will receive the first issue of *The Big Canoes* along with an invitation to subscribe. If you would like to ensure that you receive it, please email Nicole Wall, NDMC Public Participation Specialist, at nwall2@unl.edu, or 402-472-6776. The newsletter and other materials on the Missouri River Basin project will be available from the Virtual Center for Decadal Climate Variability, at http://www.DecVar.org.

Researchers have identified long-distance "teleconnections" between ocean and atmospheric conditions, such as the El Niño/La Niña phenomenon, in which sea surface temperatures off the western coast of South America are linked with wet or dry years in South America, Australia, Pacific islands, and even parts of Africa. An El Niño/La Niña pattern can last for months or years. Other, less well-known patterns such as the Pacific Decadal Oscillation and the Tropical Atlantic Gradient, shift more slowly, over years or decades. CRCES is exploring connections between these long-term patterns and droughts and floods in the Missouri River Basin.

"While global climate change and its possible consequences in the 21st century grab headlines, it is easy to forget that the Earth's climate has been undergoing natural variability at multi-year to multicentury timescales for millennia, if not longer," said Vikram Mehta, CRCES, lead investigator on the project. "Among these natural phenomena, decadal climate variability has manifested itself as cycles of long-persistent droughts and floods in many parts of the world, especially in the Missouri River Basin (MRB)."